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ABSTRACT

Reported are results of a study designed to replicate a study at North Carolina State University which investigated the effectiveness of a diagnostic/prescriptive system for increasing the science achievement of university students and examined the relationship between selected student characteristics and participation in voluntary diagnosis. Questions in this study include: (1) whether achievement can be influenced by voluntary participation in diagnostic/prescriptive testing when variables such as academic aptitude, achievement motivation, locus of control, and logical thinking ability are controlled; (2) whether a relationship exists between locus of control, achievement motivation, academic aptitude or logical thinking ability and the student's voluntary use of diagnostic/prescriptive tests; and (3) whether continued participation in voluntary diagnostic/prescriptive testing is a function of the student's level of success on course examinations and/or the number of diagnostic/prescriptive tests taken. Data collected from biology students (N=107) at the University of Georgia were analyzed through general linear model programs on the SAS computer package. Results indicate that a voluntary diagnostic testing program can significantly increase university biology achievement, with the same general achievement and diagnostic/prescriptive usage trends reported in the North Carolina study also observed in this study. (CS)

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THE INFLUENCE OF VOLUNTARY DIAGNOSTIC TESTING ON SCIENCE ACHIEVEMENT: A REPLICATED STUDY

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THE INFLUENCE OF VOLUNTARY DIAGNOSTIC TESTING ON SCIENCE ACHIEVEMENT: A REPLICATED STUDY

INTRODUCTION

Background

The recent meta-analysis conducted by Yeany and Miller (1981) has shown that an instructional system which includes diagnostic feedback on achievement and prescribed remediation regularly influences science achievement. In fact, the analysis indicated that the impact of the feedback alone contributed the major share of the effect. Individual studies have shown that mandatory diagnostic prescriptive (d-p) instruction can influence the science achievement of college students (e.g., Yeany, Waugh and Blalock, 1979; Yeany, Dost and Matthews, 1980; and, Benson and Yeany, 1980). Even though these results are positive, the implementation of d-p systems in college science has been lacking. The reason for this appears to be the unwillingness or inability of college instructors to organize and maintain such an instructional system where student learning must be formally and regularly diagnosed and remediation opportunities provided. After reviewing the literature on d-p research, biology curriculum developers at North Carolina State University recognized the problem of the "reluctant" science professor. They then attempted to develop a voluntary system of diagnosis with feedback, in which success would depend more on student initiative and less on the willingness of the instructor to organize and attend to such an instructional system (Adams, 1980).

Purpose

The purpose of this study was to replicate and assess the generalizability of the study conducted at North Carolina State. This study investigated the effectiveness of a diagnostic-prescriptive system for increasing the science achievement of university students and examined the relationship between selected student characteristics and participation in voluntary diagnosis. The following research questions provided the focus of both the North Carolina study and the present study which was conducted at the University of Georgia.

1. Can achievement be influenced by voluntary participation in diagnostic-prescriptive testing when variables such as academic aptitude, achievement motivation, and locus of control and logical thinking ability are controlled?

2. Is there a relationship between the entry characteristics: locus of control; achievement motivation; academic aptitude; or, logical thinking ability and the student's voluntary use of diagnostic-prescriptive tests?

3. Is continued participation in voluntary diagnostic-prescriptive testing a function of the student's level of success on course examinations and/or the number of d-p tests taken?

PROCEDURES

Subject Selection

Subjects of this study were 107 university students enrolled in an introductory level biology course at the University of Georgia during the summer quarter of 1980. All students in the course were considered to be subjects in the study. Since the research questions centered on the effects of voluntary use of diagnostic tests, those subjects who participated in the testing and received feedback were considered to be treated; the achievement of those who did not participate represented baseline data. Regression

analysis procedures were used to adjust for selection bias inherent to voluntary participation in treatment. Table 1 provides a description of the study sample on the basis of several entry characteristics of the subjects.

Research Design

The basic research design employed in this study can be diagrammed in Campbell and Stanley notation as follows:

$$O_1 \quad O_2 \quad O_3 \quad O_4 \quad X_1 \quad O_5 \quad X_2 \quad O_6 \quad X_3 \quad O_7$$

where:

O_1 = Locus of control assessment;

O_2 = Achievement motivation assessment;

O_3 = SAT scores;

O_4 = Test of Logical Thinking;

X_1 = Diagnostic-prescriptive tests voluntarily taken on first examination topics;

O_5 = First summative examination on basic and organic chemistry, and cellular structure, and division;

X_2 = Diagnostic-prescriptive tests voluntarily taken on second examination topics;

O_6 = Second summative examination on protein synthesis, and animal development;

X_3 = Diagnostic-prescriptive tests voluntarily taken on third examination topics;

O_7 = Third summative examination on Mendelian and modern genetics.

Treatment

The diagnostic tests were offered on an optional basis in the Bioscience Learning Center. Each test consisted of 20 multiple-choice questions to check the student's achievement of the concepts; each focused on the course

objectives which were covered in the unit represented by the specific set of diagnostic tests. An example of a diagnostic test item and the feedback received by students who volunteered for diagnosis is included in Table 2. This feedback to the student was immediate. A test was scored by the student and then returned to a staff member in the Learning Center. The student received item level results of the diagnosis as well as a remediation guide in the form of a written description of why certain responses were correct and other incorrect in relation to the concept being measured.

Measurement of Student Entry Characteristics

As mentioned earlier several entry characteristics of the students were used to control for selection bias inherent in the voluntary nature of participation in treatment and to examine the relationship between these characteristics and tendencies to volunteer for diagnosis. The entry characteristics were: locus of control; achievement motivation; academic aptitude; and logical thinking (formal reasoning) ability.

Locus of control was selected as a variable with some potential to influence participation in diagnosis and prescription because the receipt of diagnostic feedback can provide the internal locus of control student with an opportunity to guide their destiny [see Rowe (1974a and 1974b) for an enlightening discussion and description of student fate control]. Locus of control was measured during the second laboratory meeting through the use of an instrument developed by Levenson (1973).

Achievement motivation was another variable which had a logical potential for influencing voluntary participation in diagnostic activities. Those students who are most highly motivated to achieve would probably be the ones to seek out various means (e.g., diagnostic feedback) for achieving

their goals. Achievement motivation was measured with the Mehrabian Achievement Motivation Scales (Mehrabian and Bank, 1978).

Academic aptitude was determined through SAT scores (both quantitative and verbal). This variable was selected because of an interest in whether students of various ability levels will also show variations in the rate of participation in voluntary diagnosis. For example, students of high ability may not be experiencing learning problems and thus may not perceive a need for achievement feedback. Therefore, they would not be likely to volunteer for diagnosis. Students who experience learning difficulties because of lower ability levels should seek out a means of improving their achievement.

Logical thinking ability was measured with the Test of Logical Thinking (TOLT). TOLT is a pencil and paper version of a series of conventional formal reasoning tasks used in Piagetian based research (Tobin and Capie, 1980). The reasons for including this variable in the study are based on recent reports that greater variations in these skills, which are related to cognitive development, exist in college age students than had previously been thought (Chiapetta, 1976). As with academic ability, variation in logical thinking ability have been shown to be related to variations in college science achievement (Yeany, Helseth and Barstow, 1980). Therefore, the variable may also be related to tendencies to participate in voluntary diagnosis.

Measurement of Science Achievement

Science achievement was defined by the scores on three multiple-choice examinations. Each examination consisted of 40 items which had been pilot tested and were judged to be valid and reliable for the course objectives. They were also judged by a panel of biology instructors and the

researchers to be valid measures of the influence of the diagnostic procedures. Reliabilities and test data are given in Table 3.

Data Analysis

All data were analyzed through general linear model programs in the SAS computer package (Helwig and Council, 1979). To assess the effects on achievement of participation in the diagnostic testing (research question #1), variations in the entry characteristics described above were entered into the regression model before the amount of voluntary participation was entered. This essentially controlled for the potential selection bias discussed earlier.

To determine the relationship between these entry variables and the level of participation in diagnosis (research question #2) all variables were entered into the regression model.

To address the question of the effects of success on prior achievement tests and the number of diagnostic test taken on subsequent participation in diagnosis (research question #3), success was operationally defined as scoring 80% or above on an achievement test. Lack of success was defined as a score below 60%. Subjects who scored at the 70-79% level were dropped from this component of the analysis. These data were analyzed by regressing the level of success, the number of diagnostic tests taken, and their interaction against the number of diagnostic tests subsequently volunteer for.

RESULTS

In relation to the first research question, the data indicated that on the four measures of achievement, the number of diagnostic tests taken positively influenced learning ($p=.0003$, .008, .08 and .0001). Tables 4 and

5 show the results of the multiple regression upon which this conclusion was based. It should be noted that these results show only unique variance which is accounted for by a predictor variable; therefore, all variance which could be attributed to or overlapped with an entry characteristic was not predicted by the rate of participation in diagnosis. This provides the most conservative estimate of the effects of the voluntary treatment and adjusts for selection bias on the basis of entry characteristics.

In regard to the second research question about the relationship between the entry characteristics of students and their tendency to participate in voluntary diagnosis, academic ability and locus of control were the consistent predictors of the rate of volunteering for diagnosis (see Table 6). Inspection of the regression slopes indicated that in all cases: 1) quantitative ability was positively related to participation; 2) verbal ability was negatively related; and, 3) locus of control was negatively related (i.e., externals show higher involvement). It should be noted that, in this analysis, variables which did not show initial significant contribution to the model were dropped to generate a more parsimonious model.

Research question #3 focused on the effects of achievement success and prior participation on continued participation in voluntary diagnosis. Since no participation could occur prior to unit 1, this analysis examined the data from units 2 and 3 only. Table 7 provides the results of the regression analyses where the amount of voluntary participation in diagnosis and success on the prior unit test were used to predict subsequent participation. The results indicate that the best predictor of participation in Unit 2 diagnosis was the level of participation in Unit 1 ($p<.01$). Success (or lack of) on the Unit 1 exam did not influence Unit 2 participation

(p=.36). Analysis of Unit 3 data indicated a success X participation interaction. Figure 1 depicts the nature of this interaction. It appears that most students who initially choose not to participate do not change their minds on the basis of achievement success. And, students who demonstrate an initial willingness to participate continue only if they are successful achievers.

DISCUSSION

The results of this study indicate that offering a system of voluntary diagnosis with remediation suggestions is a viable and effective means for increasing the achievement of students in college science classes. Also, the diagnostic procedure seems to be attractive to the externally oriented and more quantitative student. In relation to the effects of success and prior participation on subsequent participation, the results are very logical. Students who use the procedure and are successful continue to use it; those who aren't successful do not continue to volunteer.

As mentioned earlier, d-p instructional systems have proved to be effective means of improving science achievement. But, their implementation at the college level has been nil. The reason being that many college professors assign low priority to the implementation of variations in their instructional procedures. The use of a voluntary d-p system holds some promise for offering an effective technique with limited involvement from the professor beyond the stage of development. The process can be carried out through media or learning centers as an activity which is congruent with their intended purpose. As with other d-p systems, the time and energy required for development are moderate but the operating "costs" are low. Both are easy to justify in terms of positive effects on science learning.

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Table 1

DESCRIPTIVE DATA FOR THE STUDY SAMPLE ON SELECTED ENTRY CHARACTERISTICS

	Variable	N	$\bar{X}$	S.D.	MIN	MAX
LOC	Internal	103	35.7	6.3	7	46
	Power	103	18.7	8.2	1	43
	Chance	103	17.4	8.3	0	39
	Ach Mot	103	57.7	31.7	-19	136
	SAT-V	94	447	88	240	740
	SAT-Q	94	473	85	260	670
	GPA	106	2.6	.6	1.3	4.0

Table 2

AN EXAMPLE OF A DIAGNOSTIC ITEM AND APPROPRIATE REMEDIATION

Item
Concentrations of DDT which were once effective as an insecticide are no longer sufficient. Which is the best explanation for this phenomenon? A. The DDT has lost its potency. B. Insects are immune to DDT because they grow up in an environment contaminated with it. C. Only those insects with adaptations for detoxifying DDT have survived and reproduced. D. Mutations conferring resistance occur more frequently now than ever before.
Remediation Suggestion
(C) ____ Review the concept of preadaptation. The environment does not "cause" genetic change, it merely exerts selective pressure on pre-existing adaptations. Organisms with favorable adaptations have the best chance to survive and pass on their genetic material to the next generation.

Table 3

DATA ON THE THREE ACHIEVEMENT EXAMS
USED IN THE STUDY

Exam	$\overline{X}$	S_m	r
1	26.75	2.54	.88
2	26.28	2.54	.82
3	22.65	2.66	.78

Table 4

RESULTS OF REGRESSION ANALYSES ON THE EFFECTS OF PARTICIPATION IN VOLUNTARY DIAGNOSTIC TESTING ON COLLEGE BIOLOGY ACHIEVEMENT IN UNIT 1 AND UNIT 2

	Unit 1 Chemistry, Cell Structure and Division				Unit 2 Animal Development and Reproduction, and Protein Synthesis			
Source	DF	Type IV SS	F Value	PR > F	DF	Type IV SS	F Value	PR > F
DIAGNOSIS	1	573.79	14.41	0.01	1	215.61	7.29	0.01
TOLT	1	20.49	0.51	0.47	1	13.27	0.45	0.50
INTERNAL	1	87.63	2.20	0.14	1	46.09	1.56	0.21
CHANCE	1	1.75	0.04	0.83	1	3.96	0.13	0.71
POWER	1	8.05	0.20	0.65	1	23.48	0.79	0.37
TOLT*CHANCE	1	9.21	0.23	0.63	1	33.26	1.13	0.29
TOLT*INTERNAL	1	52.65	1.32	0.25	1	0.17	0.01	0.93
TOLT*POWER	1	0.52	0.01	0.90	1	16.95	0.57	0.45
ACHMOT	1	0.93	0.02	0.87	1	25.71	0.87	0.35
TOLT*ACHMOT	1	54.80	1.38	0.24	1	0.35	0.01	0.91
INTERNAL*CHANCE	1	30.64	0.77	0.38	1	90.60	3.06	0.08
INTERNAL*POWER	1	1.60	0.04	0.84	1	23.54	0.80	0.37
INTERNAL*ACHMOT	1	6.60	0.17	0.68	1	40.21	1.36	0.24
CHANCE*POWER	1	7.20	0.18	0.67	1	115.09	3.89	0.05
CHANCE*ACHMOT	1	10.57	0.26	0.61	1	47.96	1.62	0.20
POWER*ACHMOT	1	3.22	0.08	0.77	1	30.93	1.05	0.30
	Model F = 2.70 R^2 = .36			p = .002	Model F = 2.66 R^2 = .34			p = .002

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Table 5

RESULTS OF REGRESSION ANALYSES ON THE EFFECTS OF PARTICIPATION IN VOLUNTARY DIAGNOSTIC TESTING ON COLLEGE BIOLOGY ACHIEVEMENT IN UNIT 3 AND TOTAL ACHIEVEMENT

	Unit 3 Classical and Modern Genetics				Total Achievement			
Source	DF	Type IV SS	F Value	PR > F	DF	Type IV SS	F Value	PR > F
DIAGNOSIS	1	83.75	3.11	0.08	1	5044.00	15.73	0.01
TOLT	1	10.39	0.39	0.53	1	709.23	2.21	0.14
INTERNAL	1	50.47	1.88	0.17	1	1943.48	6.06	0.01
POWER	1	59.80	2.22	0.14	1	133.33	0.42	0.52
CHANCE	1	29.75	1.11	0.29	1	57.60	0.18	0.67
ACHMOT	1	14.92	0.55	0.45	1	1.97	0.01	0.93
TOLT*INTERNAL	1	17.58	0.65	0.42	1	1603.61	5.00	0.02
TOLT*POWER	1	3.40	0.13	0.72	1	120.42	0.38	0.54
TOLT*CHANCE	1	98.24	3.65	0.05	1	966.08	3.01	0.08
TOLT*ACHMOT	1	16.57	0.62	0.43	1	678.70	2.12	0.14
INTERNAL*POWER	1	39.35	1.46	0.23	1	470.51	1.47	0.22
INTERNAL*CHANCE	1	2.04	0.08	0.78	1	50.18	0.16	0.69
INTERNAL*ACHMOT	1	3.34	0.12	0.72	1	5.23	0.02	0.89
POWER*CHANCE	1	6.93	0.26	0.61	1	1.27	0.00	0.94
POWER*ACHMOT	1	4.57	0.17	0.68	1	308.87	0.96	0.32
CHANCE*ACHMOT	1	1.64	0.06	0.80	1	490.13	1.53	0.21
	Model F = 2.20			p = .001	Model F = 2.96			p = .0000
	R^2 = .30				R^2 = .35			

Table 6

RESULTS OF ANALYSIS TO DETERMINE THE EFFECTS OF ENTRY CHARACTERISTICS ON PARTICIPATION IN VOLUNTARY DIAGNOSTIC TESTING DURING EACH UNIT OF THE STUDY

	Source	DF	Type IV SS	F Value	PR > F
Unit 1	LOC	1	10.49	4.22	0.042
	SAT-Q	1	13.18	5.31	0.023
	SAT-V	1	3.55	1.43	0.235
			Model F = 3.13		p = .03
			R^2 = .10		
Unit 2	ACHMOT	1	0.53	1.65	0.202
	SAT-Q	1	0.95	2.95	0.089
	SAT-V	1	1.73	5.39	0.022
			Model F = 2.43		p = .06
			R^2 = .08		
Unit 3	LOC	1	0.54	6.63	0.011
	SAT-Q	1	0.38	4.65	0.033
	SAT-V	1	0.29	3.54	0.059
			Model F = 4.10		p = .009
			R^2 = .12		
Total Achievement	LOC	1	25.10	4.26	0.042
	SAT-Q	1	34.18	5.80	0.018
	SAT-V	1	20.25	3.44	0.067
			Model F = 3.55		p = .02
			R^2 = .11		

Table 7

RESULTS OF ANALYSES PERFORMED TO PREDICT PARTICIPATION IN VOLUNTARY DIAGNOSIS ON THE BASIS OF PRIOR PARTICIPATION AND RESULTANT ACHIEVEMENT

Unit 2					Unit 3				
Source	DF	Type I SS	F Value	PR > F	Source	DF	Type I SS	F Value	PR > F
DIAGNOSIS1	1	14.03	57.13	0.01	DIAGNOSIS2	1	1.56	40.73	0.01
SUCCESS1	1	0.24	1.01	0.31	SUCCESS2	1	0.18	4.77	0.03
CMT1*SUCCESS1	1	0.01	0.01	0.92	CMT2*SUCCESS2	1	0.37	9.85	0.01
DIAGNOSIS1	1	2.39	9.74	0.01	DIAGNOSIS2	1	0.00	0.00	1.00
SUCCESS1	1	0.20	0.82	0.36	SUCCESS2	1	0.06	1.66	0.20
CMT1*SUCCESS1	1	0.01	0.01	0.92	CMT2*SUCCESS2	1	0.37	9.85	0.01

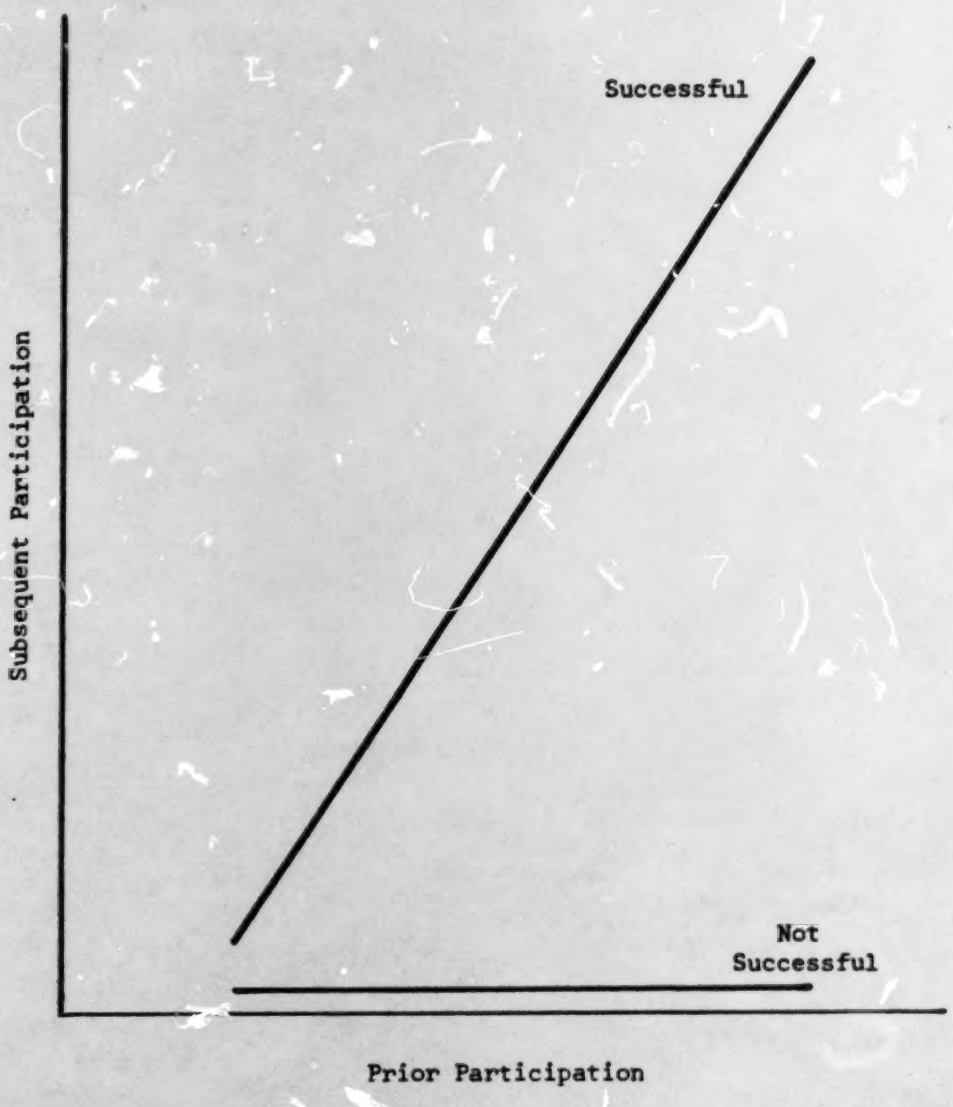

Figure 1. A Graphic Representation of the Interaction Between Participation in Diagnosis and Achievement Success as Measured in Subsequent Participation.